Postmenopausal Spinal Osteoporosis: Flexion versus Extension Exercises

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ABSTRACT. Sinaki M, Mikkelsen BA: Postmenopausal spinal osteoporosis: flexion versus extension exercises. Arch Phys Med Rehabil 65:593–596, 1984.

• Fifty-nine women with postmenopausal spinal osteoporosis and back pain were instructed in a treatment program that included extension exercises (E) for 25 patients, flexion exercises (F) for 9, combined (E + F) exercises for 19, or no therapeutic exercises (N) for 6. Ages ranged from 49 to 60 years (mean, 56 years). Follow-up ranged from one to six years (means for the groups, 1.4 to 2 years). All patients had spine x-ray studies before treatment and at follow-up, at which time any further wedging and compression fractures were recorded. Additional fractures occurred as follows: group E, 16%; F, 89%; E + F, 53%; and N, 67%. In comparison with group E, the occurrence of wedging or compression fractures was significantly higher in group F ($p<0.001$) and group E + F ($p<0.01$). This study suggests that a significantly higher number of vertebral compression fractures occur in patients with postmenopausal osteoporosis who followed a flexion exercise program compared with those using extension exercises. Extension or isometric exercises seem to be more appropriate for patients with postmenopausal osteoporosis.

Postmenopausal osteoporosis is the subject of much research and debate concerning its medical treatment and possible prevention. Some researchers have investigated the use of fluoride and calcium to stimulate new bone formation and to prevent vertebral fractures.[9] Others have studied lifelong calcium intake in relation to the development of osteoporosis.[4] Several studies have also been devoted to methods of diagnosis[13] and quantification of disease.[8–10] Yet, little is in the medical literature about the correct use of exercise and physical therapy to prevent vertebral fractures in women with the disease.

One study showed that there is no relationship between muscle strength and bone density in age-related loss of bone mineral.[12] Other studies have shown a clear relationship between muscle mass and bone mass.[6] Smith and associates[14, 15] demonstrated a 2% increase in forearm bone mineral content in elderly women after a program of physical exercise for three years. Krølner and colleagues[7] evaluated the skeletal effects of physical training in a controlled trial involving 31 healthy women. Their data suggest that physical exercise can inhibit involutional bone loss from lumbar vertebrae in healthy women.

Our study is a retrospective review of the effects of an exercise regimen on 59 patients with proven postmenopausal osteoporosis.

SUBJECTS AND METHODS

Fifty-nine consecutive patients with a confirmed diagnosis of postmenopausal osteoporosis of the spinal column who had been seen at this clinic from 1969 through 1981 were studied. Ages ranged from 49 to 60 years (mean, 56 years). The criteria for inclusion were as follows: (a) radiographic diagnosis of osteoporosis; (b) age between 49 and 60 years (to avoid inclusion of older patients with multiple medical problems or those who could not comply with an exercise program); (c) no history of cancer, metabolic bone disease, or any condition (such as a neurogenic, myopathic, or connective tissue disorder) that could cause secondary osteoporosis; (d) no intake of steroids; and (e) no other major health problem that could cause difficulties with execution of the exercise programs.

Correlation of Radiographic Evaluation With Exercise*

Exercise group	Comparison of first and second radiographs			
	Same	Worse	Total	% worse
E	21	4	25	16
F and E + F	10	18	28	64
Total	31	22	53	42

*$\chi^2_1 = 12.69$, $p<0.001$.

At the initial evaluation and diagnosis of postmenopausal osteoporosis, each patient had been seen by an internist and a physiatrist. An anteroposterior and a lateral roentgenogram were made of the thoracic and lumbar spinal regions for each patient. Diagnosis of osteoporosis was made on the basis of these films according to the following criteria: (a) radiologic evidence of decreased bone density, (b) biconcavity of vertebral bodies with overextension of disks, (c) different stages of collapse of vertebral bodies (ie, wedging, compression fractures), and (d) kyphosis and decreased height. When collapse of vertebral bodies was not present, the patient was not excluded if the other radiographic criteria listed were present. Follow-up evaluations were done at one to six years (mean, 1.5 years), at which time new spinal roentgenograms were taken.

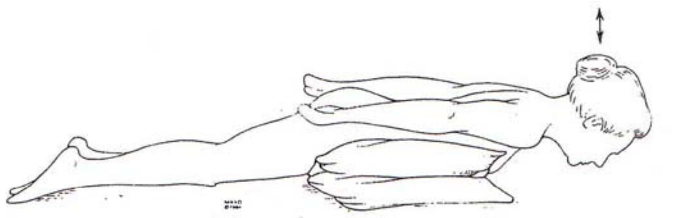

Fig 1—Back extension exercise (group E) performed in prone position.

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Fig 2—Extension exercise (group E) in sitting position used for patients with severe osteoporosis to avoid or minimize pain.

The 59 subjects were placed in one of four groups on the basis of therapeutic back exercises prescribed by the physiatrist t the time of initial evaluation: spinal extension (E), 25 patients (43%); spinal flexion (F), 9 patients (15%); both exten- on and flexion (E + F), 19 patients (32%); and neither flexion nor extension (N), 6 patients (10%). All treatment programs included infrared heat and massage. Selection of an exercise program was on the basis of each physiatrist's method of treatment for postmenopausal spinal osteoporosis.

The program in group E consisted of exercises to strengthen erector muscles of the spine. Patients were instructed to perform these exercises while prone or sitting (fig 1 and 2). The program in group F consisted of exercises that involved abdominal muscles, such as sit-ups (fig 3). Patients of this group also performed stretching of the erector spine muscle (fig 4). Group E + F performed both extension and flexion exercises as described. Patients in group N were instructed to follow proper posture principles during their activities of daily living.[11] Some patients from this group were also instructed in exercises to contract their abdominal muscles without performing the actual sit-ups as performed by group F. These patients tried isometric contraction of abdominal muscles (fig 5). All patients were instructed to avoid lifting objects weighing more than 10 pounds and to use flexion of the knees rather than the spine for bending activities.

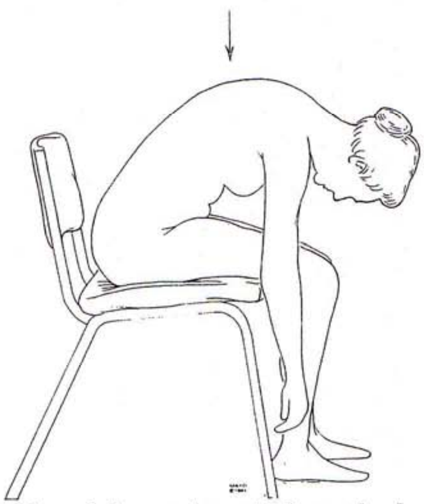

Fig 4—Stretching of the erector spinal muscles by flexing the spine.

Initial and follow-up roentgenograms were compared, and development of further wedging or compression fracture at follow-up evaluation was recorded. Radiographic evaluations were done by a radiologist, an internist, and one physiatrist (MS). All comparisons were made without knowledge of the exercise prescription to eliminate bias in judgment. Also noted from the patient's records at both initial and follow-up evaluations were laboratory values for serum creatinine, calcium, phosphorus, and alkaline phosphatase to ensure normal values.

RESULTS

Maximum fracture rates were recorded at T7 (20.3% wedging and 20.3% compression), T8 (18.6% wedging and 16.9% compression), and T6 (15.3% wedging and 13.6% compression) (fig 6).

When the roentgenograms from the follow-up evaluation were compared with those from the initial evaluation, 56% of the subjects had no further wedging or compression of their vertebrae and 44% did have further wedging and compression fractures. In group E 84% showed no further wedging or compression of vertebrae; the mean duration of follow-up for

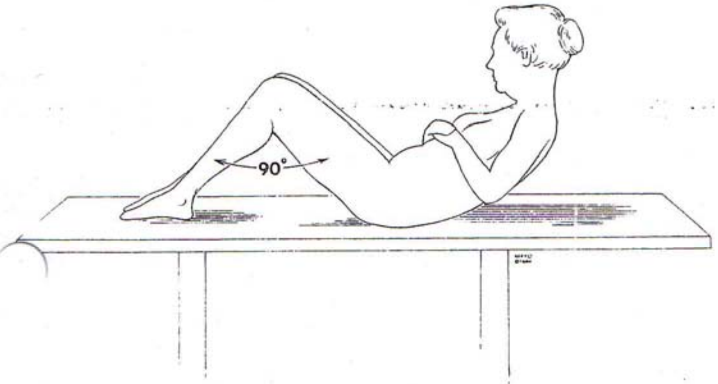

Fig 3—Sit-ups to improve abdominal muscle strength (group F).

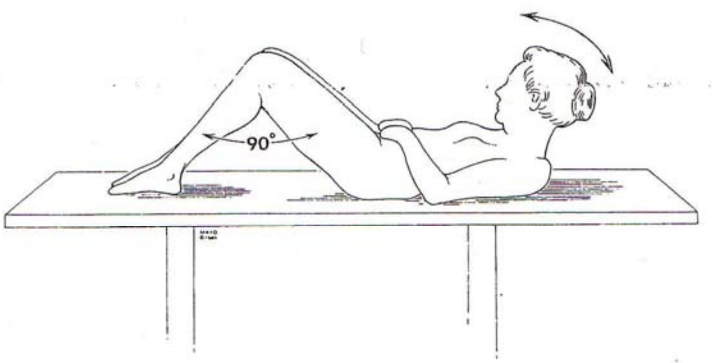

Fig 5—Strengthening abdominal muscles isometrically.

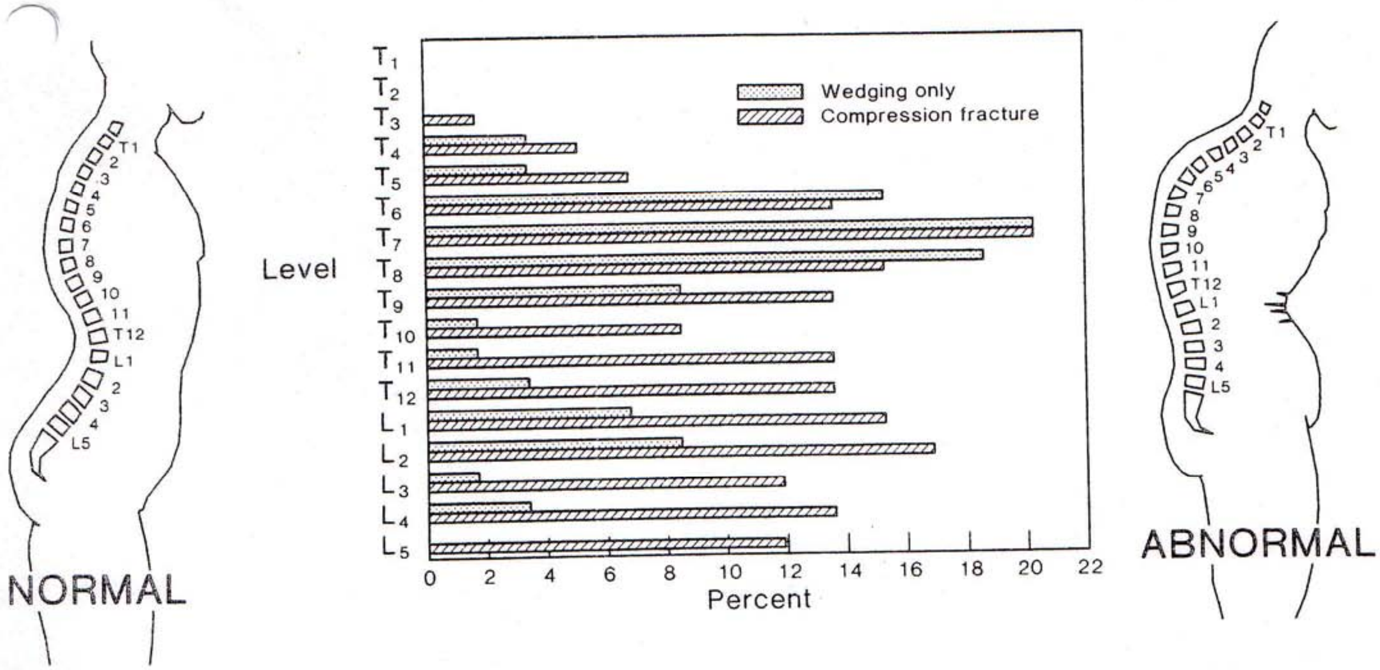

Fig 6—Incidence of wedging and compression fractures at various levels at the initial evaluation.

hi roup was 1.4 years. In group F only 11% had no further ve ig or compression; the mean duration of follow-up was .6 ars. In group E + F, 47% remained unchanged; the ne uration of follow-up was 1.4 years. In group N 33% ad no further wedging or compression; the mean duration of ollow-up was 2.3 years. The p values for these differences vere as follows: E and F, $p<0.001$; E and E + F, $p<0.01$; and E + F, NS; combined E + F and F versus E, $p<0.001$ table).

DISCUSSION

In postmenopausal spinal osteoporosis, for which a defini- ively effective medical treatment is still not known, preven- ion of further bone loss and fractures is an important goal. Attempts at prevention must be aimed at diminishing the num- er and rate of vertebral compression fractures (the most com- non disabling deformity of osteoporosis). These lesions lead o dorsal kyphosis ("dowager's hump"), progressive decrease n height, and often acutely painful and disabling fractures in he dorsal and lumbar regions.

Although a correlation between bone mineral content and nuscle strength was not found in one study,[12] other studies ave found a strong correlation between muscle mass and bone nass.[5] Abramson and Delagi[2] reported that muscle contraction laced the stress on bone that is needed to prevent disuse steoporosis and that such exertion was more effective than ust weight-bearing in this regard. Prolonged inactivity is also n to cause muscle atrophy and bone loss.[1] Therefore, he eutic exercises may play a role in the treatment of pa- ier ith osteoporosis. Exercises may also help in avoiding dd nal disuse bone loss when osteoporosis already exists. A recent controlled study[7] demonstrated the effectiveness of hysical exercise in prophylaxis against involutional vertebral one loss in a group of women 50 to 73 years old. Increase n total body calcium has been shown in patients who follow a one-hour exercise program three times a week.[3] Increasing abdominal muscle strength is also important in providing support to the spine.[5]

Not all types of exercise are appropriate for these patients because of the fragility of their vertebrae. Exercises that place flexion forces on the vertebrae, whether or not accompanied by extension strengthening exercises, tend to cause an increased number of vertebral fractures in these patients. This finding has a number of implications for patients' activities in daily living and recreational pursuits. If an exercise program is to be prescribed for patients with spinal osteoporosis, a cautious approach is recommended. If a therapeutic exercise program is used, extension or isometric back and abdominal strengthening exercises seem more appropriate than flexion exercises.

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ABSTRACTS of selected literature

Tesch PA, Thorsson A, Kaiser P: Muscle capillary supply and fiber type characteristics in weight and power lifters. J Appl Physiol 56:35-38, 1984.

● Muscle tissue samples were obtained from vastus lateralis muscle of elite weight/power lifters (WL/PL, $n = 8$), endurance athletes (EA, $n = 8$), and nonathletes (NA, $n = 8$). Histochemical stainings for myofibrillar ATPase, NADH-tetrazolium reductase, and amylase-periodic acid-Schiff, respectively, were undertaken to assess relative distribution of fast-twitch (FT) and slow-twitch (ST) muscle fiber types, fiber size, and capillary supply [capillaries per fiber ($\text{cap} \cdot \text{fib}^{-1}$) and capillaries per mm^2 ($\text{cap} \cdot \text{mm}^{-2}$)]. Fiber type distribution in WL/PL, EA, and NA averaged 59 ± 6 (SD), 40 ± 11, and 61 ± 10% FT. Values for mean fiber area and FT/ST area were significantly greater in WL/PL compared with values obtained in EA and NA. Similar values for $\text{cap} \cdot \text{fib}^{-1}$ were observed in WL/PL (2.06 ± 0.74) and NA (2.16 ± 0.34). EA exhibited greater $\text{cap} \cdot \text{fib}^{-1}$ (3.11 ± 0.73) than WL/PL (NS) and NA ($P < 0.01$). However, $\text{cap} \cdot \text{mm}^{-2}$ in WL/PL (199 ± 29) was lower than in EA (401 ± 61, $P < 0.001$) and NA (306 ± 29, $P < 0.01$). It is suggested that heavy resistance training in contrast to endurance training does not result in increased capillary density. Instead, as a consequence of fiber hypertrophy induced by muscle overloading, capillary density is decreased.

Dorfman LJ: The distribution of conduction velocities (DVC) in peripheral nerves: a review. Muscle and Nerve 7:2-11, 1984.

● Recent advances in digital signal processing have permitted the development of clinically relevant, noninvasive, computer-based methods for estimating the distribution of conduction velocities (DCV) in motor, sensory, and mixed populations of large myelinated nerve fibers. All currently available methods incorporate explicit and implicit assumptions about the nature of the unit impulses under study. Preliminary investigations using DCV methods have clarified some issues concerning conduction of impulses in the different fiber subpopulations of normal and diseased human nerves. In the presence of severe nerve disease, DCV analysis is usually either impractical or superfluous; additional studies are needed to define its range of clinical applicability. Extension of this technology to clinical analysis of small myelinated and unmyelinated fiber populations will require improvements in the techniques of nerve stimulation and recording.

Raven PB, Rohm-Young D, Blomqvist CG: Physical fitness and cardiovascular response to lower body negative pressure. J Appl Physiol 56:138-144, 1984.

● Fourteen young male volunteers (mean age 28.1 yr) underwent maximal exercise performance testing and lower body negative pressure (LBNP) challenge to −50 Torr. Two distinct groups, fit (F, $n=8$), mean maximal aerobic capacity ($\dot{V}_{O_{2\max}}$) = 70.2 ± 2.6 (SE) ml O_2 $\text{kg}^{-1} \cdot \text{min}^{-1}$, and average fit (AF, $n=6$), mean $\dot{V}_{O_2\ \max}$ = 41.3 ± 2.9 ml O_2 $\text{kg}^{-1} \cdot \text{min}^{-1}$, $P < 0.001$, were evaluated. Rebreathing CO_2 cardiac outputs, heart rate (HR), blood pressure (BP), and leg circumference changes were monitored at each stage of progressive increases in LBNP to −50 Torr. The overall hemodynamic responses of both groups of subjects to LBNP were qualitatively similar to previous findings. There were no differences between F and AF in peripheral venous pooling as shown by a leg compliance (Δ leg volume/Δ LBNP) for the F of 12.6 ± 1.1 and for the AF 11.6 ± 2.0, $P > 0.05$. The F subjects had significantly less tachycardic response [ΔHR/Δ systolic BP of F = 0.7 beats/Torr] to LBNP to −50 Torr than the AF subjects [ΔHR/Δ systolic BP of unfit (UF) = 1.36 beats/Torr], $P < 0.05$. In addition, overall calculated peripheral vascular resistance was significantly higher in the AF subjects ($P < 0.001$), and there was a more marked decrease in systolic BP of the F subjects between the LBN pressures of −32 to −50 Torr. We concluded that the reflex response to central hypovolemia was altered by endurance exercise training.

Booth FW, Gollnick PD: Effects of disuse on the structure and function of skeletal muscle. Med Sci Sports Exerc 15:415–420, 1983.

● The purpose of the paper described is to briefly review some of the effects of reduced muscle use on the structure and function of human and animal skeletal muscle. A loss in muscle strength has been observed in astronauts after space flight. On earth joint fixation of human limbs results in losses in muscle mass, in the cross-sectional area of both fiber types, and in the activities of mitochondrial enzymes. Methods that reduce muscular activity of animals also produce muscle atrophy. Fixation of the limb joints in position where the muscles are maintained less than resting length results in an atrophy in slow-twitch muscle. Associated with this atrophy are decreases in sarcomere number, fiber corss-sectional area, protein synthesis, and insulin responsiveness for the uptake of 2-deoxyglucose by muscle. Suspension of animals in a horizontal or head-down position is also a method being used currently for unloading muscles and producing alterations in development. In the future, the animal and human model should identify the mechanisms responsible for a decrease in muscle function when the muscle undergoes a decrease in usage.